Title: Marine Life -- Adaptations for Keeping Warm

Brief Overview:

In this lesson, students (grades 6-8) will lower the freezing point of a substance and demonstrate how it can stay liquid when it normally would be solid. Students will be able to describe how Antarctic fish are able to survive below freezing temperatures. Students will be able to understand how unique biological and physiological adaptations are essential for survival in one environment but detrimental to survival in another environment. Students will be able to compare an earlier prediction with actual observed results of their experiment.

Links to NCTM 2000 Standards:

- **Mathematics as Problem Solving, Reasoning and Proof, Communication, Connections, and Representation**
  Students will compute rates of expansion for freezing ice when given different time indices, i.e., one hour, twelve hours, etc. They will be able to use physical science to reason why we put salt on roads in winter or why we put salt in ice cream when making old fashion ice cream. Students also will be able to make connections to real-life situations regarding heat loss or gain. Last of all, they will use chemical experimentation to model actual conditions in Antarctic marine life.

- **Number and Operation**
  Students will use basic operations to compute the rate of ice expansion. They will be able to convert Celsius to Fahrenheit temperature readings.

- **Measurement**
  Students will use the triple beam balance to measure the exact mass of a chemical compound to use. They will estimate when the substance has reached the saturation and supersaturation point.

Links to National Science Education Standards:

- **Unifying Concepts and Processes**
  Students will develop abilities aligned with the concepts and processes of evolution and equilibrium, as seen in the adaptation of the fish with antifreeze molecules to life in the icy ocean water.

- **Science as Inquiry**
  Students will be able to understand the crystallization phenomena by observing a frozen and non-frozen apple over a 2-3 day period.

- **Physical Science**
  Students will be able to understand the concept of heat gain/loss.

- **Life Science**
  Students will be able to compare consequences of adaptation versus non-adaptation for survival.

Links to Maryland High School Science Core Learning Goals:

- **Concepts of Biology**
  Antarctic marine life have adapted to survival in freezing waters through the development of anti-freeze molecules which consist of glycopeptides.

Other marine life have developed the ability to shunt blood away from dorsal areas to conserve body heat (counter-current heat exchange).

Grade/Level:

Grades 6-8

Duration/Length:

Two to three days

Prerequisite Knowledge:

- Multiplication process
- Using a triple balance beam
- Using a graduated cylinder to measure liquid

Student Outcomes:

Students will:

- lower the freezing point of a substance and demonstrate how it can stay liquid when it would normally be solid.
- describe how fish are able to survive below freezing temperatures.

Materials/Resources/Printed Materials:

- For each group of 3/4 students-- Handout: Fish With Antifreeze Research Packet
  Salt Concentration - Background Reading
- Test tube and holder
- 600 ml beaker or glass jar
- Test tube (approx. 20 by 120 mm)
- Goggles
- Water
- Laboratory balance/lab scale
- Stirring rod
- Sodium thiosulfate crystals

Development/Procedures:

1. **Review** "The Effect of Salt Concentration on the Freezing Point of Water". Note that increasing the salt concentration means that water can stay liquid below 0 degrees Celsius. Discuss how animals might survive in these below freezing temperatures. This is the first of three labs in which we will look at adaptations that help animals live in such cold conditions.

2. **Read** through background materials with students (background materials from *Live From Antarctica 2*, http://www.edc.org/~nross/PTK/main/t_guide).

3. **Review** safety precautions and procedures and carry out experiment with students.
   NOTE:
   To save time, you should saturate the solution at room temperature ahead of time, and only have the students perform the supersaturation).

4. **Compare** results and form conclusions at the end of the activity.

• Have students read through the entire procedure and predict what will happen. The teacher may provide the attached Student Worksheet.

Procedure:

1. **Place** 2 ml water in test tube.
2. **Mass** 15 grams of sodium thiosulfate and put 4 crystals in the water in the test tube.
3. **Create** a saturated solution at room temperature, stirring and adding more crystals until no more will dissolve.
4. **Gently** heat the solution, adding the remaining crystals until all have been dissolved in the test tube. Be sure that no undissolved bits of sodium thiosulfate remain in the test tube.
5. **Place** the test tube in a beaker of cool water so the solution can cool to room temperature without moving.
6. **When** the solution still is as clear as water but the test tube feels cool to the touch, you have created a supersaturated solution. This solution is a liquid at a temperature below where it normally becomes a solid.
7. **Carefully** lift the test tube out of the beaker of water and feel the temperature of the lower half of the tube. How does it feel?
8. **Drop** a crystal of sodium thiosulfate into the test tube and watch what happens. Feel the temperature of the lower half of the test tube as the change takes place.

Record your observations.

Conclusions:

Did this investigation support your original prediction? ____________________

If not, how was it different?

Assessment:

Students should compare their predictions to actual results and observations. Students should be encouraged to discuss results and conclusions with other students in the class. The teacher may use chart paper to record conclusions offered by the students. The class should consider those conclusions that coincide with information from the background material read previously.

Extension/Follow Up:

Have students freeze an apple at home and bring it to class to thaw. Place it next to an apple that has not been frozen and observe it over the next 2-3 days. What happens? Which apple rots faster? Why? (The cell walls of the frozen apple broke when liquid in the apple cells expanded upon freezing, thus accelerating rotting.)

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STUDENT WORKSHEET

NAME:_____________________________ DATE:__________

Marine Life -- Adaptations for Keeping Warm

Read through the entire procedure and predict what will happen.

Procedure:

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8. **Drop** a crystal of sodium thiosulfate into the test tube and watch what happens. Feel the temperature of the lower half of the test tube as the change takes place.

Prediction:

Now go back and follow the procedure for completing the lab activity.

Record your observations.

Conclusions:

Did this investigation support your original prediction? ___________________

If not, how was it different?

Assessment:

Compare your predictions to actual results and observations. Discuss results and conclusions with other students in the class. Consider those conclusions that coincide with information from the background material read previously.

Name________________________
Date___________________Pd. _____

MARINE LIFE
ADAPTATIONS FOR KEEPING WARM
FISH WITH ANTIFREEZE

Background (from *Live From Antarctica 2*, http://www.edc.org/~nross/PTK/main/t-guide):

The temperature of the Southern Ocean rarely rises above 2 degrees Celsius. McMurdo Sound averages -1.87 degrees C, and ranges between -1.4 and -2.15 degrees Celsius. Arthur Harbor is relatively similar in size of temperature fluctuation. From December through February, temperatures don't increase much, ranging from -1.9 degrees C to -1.8 degrees C. In such sub-freezing conditions, why don't fish freeze when their blood is much like fresh water? Is it possible for fish to be cooled below the freezing point of water, and yet for their bodily fluids to remain liquid?

Under special experimental conditions, fish have been observed functioning in ice-free cold salt water at a temperature of -6 degrees Celsius! Research (largely pioneered by Art DeVries, who appeared in the first Live From Antarctica series), has found that these fish have eight types of anti-freeze molecules which bathe the interior surface of their skin, acting as a barrier to ice propagating in from outside. When the anti-freeze molecules are not present, ice filters through their skin at these temperatures and crystallizes (freezes) their blood and tissues.

The chemically supersaturated solution begins to crystallize around the "seed" (the sodium thiosulfate crystal dropped in, step 8) immediately and continues to do so until all the chemical, which is normally solid (touch the tube, to feel heat being released), dissolves. This is very similar to what happens to water. Heat is added to melt ice, and heat is given off when water solidifies back into ice. The reaction takes place below our body temperature so we cannot feel it.

Fish with blood containing sugars and salts, have a freezing plateau below that of fresh water (probably approx. -0.8 degrees Celsius). Antarctic fish have the ability to supercool (-2.2 degrees Celsius) under ice in McMurdo Sound without crystallizing (freezing). Thus, they can live under pack ice where salt water is below the freezing temperature of fresh water, but only so long as no ice enters their body. They crystallize if they cool by as little as 0.1 degrees Celsius when an ice crystal penetrates the skin and seeds the reaction.